Darryl: Good afternoon, welcome to the Compressed air Assessment Basics webinar. It's hosted by the Department of Energy and the Federal Management Program. Could you give me another slide Tom?

Tom: Yep, there.

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Darryl: Just a few background things, if you would please mute your phone or your microphone and that'll keep our background noise down. Obvious for the screen and better connectivity keep your viewing area clean, wireless devices do have a problem with interference. We are recording this and slides will be sent out after the webinar is over and if you fill out the course evaluation, there are two professional development hours available for attending this webinar, next please.

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The program again is hosted by the Federal Energy Management Program and today we will be looking at items under the technology deployment area. If you'll look at your screen and again slides will be provided. You will find the web links to get additional information, next.

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Again, the Office of Energy Efficiency and Renewable Energy does work to strengthen our energy security, our environmental quality and the economic vitality in our public and private partnerships.

Again, you can see that at www.eere.energy.gov. next.

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The goal is to enhance our efficiency and productivity, bring clean and reliable and affordable energy technology to the marketplace and make a difference in our every day lives and in the choices that we make in living and improving our quality of life, next.

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If you need additional information, you can contact Tom Wenning, wenningtj@ornl.gov or you can find the link for the Industrial Technologies Program, which provides an additional amount of information on many of DOE's software tools.

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You will see that there's a progression through our public laws and Executive Orders that through implementation if we do this right, we'll provide cost of effective energy management and some investment practices to enhance our energy security and our environmental stewardship. And those progressing from 1975 through 2010 and starting with the Energy Policy and Conservation Act leading up through Executive Order 13514, next.

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Stewardship, although necessary is also a very smart thing to do. Industrial motor systems account for a very large portion of the electric consumption in this country, they are the single largest electrical end-use category in our economy in the industrial sector and they account for about 25% of U.S. electric sales and over 60% of that energy – that electricity – goes into fluid handling in the form of pumps, fans, compressed air and other fluids even refrigeration, next.

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Now to get started on that path to an assessment, and on the path to savings, one of the things that we have to look at are what are the major components of an assessment and then look at a useful tool to help qualify the potential savings. Today, we're going to be talking about AIRMaster+ and the benefits and some of the tools that support your use of AIRMaster+. Our speaker will be Tom Taranto, next please.

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I'm getting a little bit ahead of myself. Tom Taranto, Data Power Services. Tom's a qualified AIRMaster+ and compressed air Tool Assessment. He does both the one and three-day Assessment Workshops. Three-day means the Qualified Specialist – which does plan assessment for the Save Energy Now Program. You can see his contact information. Tom was also very, very instrumental in helping to develop the ASME standard on compressed air Assessments, next.

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So, without any further ado, I'll turn it over to Tom right now.

Tom: Okay, Darryl, thanks very much. I appreciate everyone attending today and I certainly look forward to spending the next two hours or so with you. You have chat windows and a question window where you can type in questions. Darryl will be monitoring that and we'll have some time towards the end for questions and answers. So, as Darryl mentioned, we're going to be talking about compressed air system basics.

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I want to start out with why is compressed air important, certainly for facilities with manufacturing equipment and support equipment, compressed air is a power source that is used universally throughout a wide range of industries and applications and so it certainly important and vital to successful operation. It's also energy-intensive energy-source resource and therefore, lends itself well to improvements through assessing the system and the overall performance, making baseline measurements, and looking at the opportunities for compressed air savings. Then we'll be talking about the actual software tools themselves, both LogTool and AIRMaster+ and we will wrap up today looking at a short case study for an actual assessment that was performed.

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The equipment cost and maintenance is where very often the majority of attention is put when trying to control cost in an compressed air system, yet if you look at a 10-year life of an air compressor over 75% of the total cost of owning and operating that air compressor is reflected in the energy consumption, usually electricity, that the compressor will use and so it is a much more lucrative investment to work with the efficiency of the system than to spend time trying to pinch a few pennies on equipment cost or maintenance cost.

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If we follow the energy flow through an air compressor and we follow a 100 kW coming in about 5% of that is loss to the motor and drive efficiency.

80% – that's 80 kW out of a 100 goes away as heat of compression and we all know from being around air compressors that one thing they do when they run is get hot and actually compressors are much more efficient at creating heat than they are at a creating compressed air energy. Only about 15% of the kilowatts that goes in – that's 15 kW out of a 100 – is actually delivered out of the compressor room to the facility as compressed air energy.

And then if you follow that path, you find that we have pressure loss in the system, leakage, artificial demand, which is increase demand at higher pressure and inappropriate uses and it's very common that about half of the 15% that gets produced goes to waste and the actually productive use is somewhere between 5 and 10% of that 100 kW input. So, here we are putting a 100 kW in the compressor and probably using about 5 or 7 ½ kW out of the 100 to actually do something productive.

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Why is it important? The problems reported with compressed air systems. Low system pressure is 25% of those polled said they had low pressure either system wide or at local points in the system. Water in the air. 50% of the people polled by a Department of Energy related to compressed air systems said, "They had water in the air." So, in a well managed system, not only do we save energy, but we can correct these problems of pressure fluctuation and air quality.

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How do we do it? We take a systems approach. In the system's approach, we step away from looking at individual components – look at the bigger picture. The best way to start is with a block diagram. A block diagram is a simple diagram. It is not a piping diagram or process instrumentation diagram those are way to complex. What we want to do is look at the key issues and opportunities in the system and assess the present cost and what the opportunity for savings are.

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If we look at the system, basically what we have is, we have energy that comes into the supply side of the system – the compressor and the filters and the equipment that's in the compressor station. That energy input is usually electricity. We convert that energy from electricity to compressed air and we supply compressed air from the compressor station through the transmission pipelines and out to the end uses and the processes and machines and tools and we use those to produce a product or to provide a function.

And so that is the basic energy flow through the system. Well, we already know here at the supply side 85% of this energy goes away in the form of waste heat, and motor and drive efficiency loses. So, what is it that we can do in the compressor room at the power-house. The producers of compressed air should focus on producing the compressed air most efficiently and even with that great of loss of energy to heat a compression, there's very often considerable opportunity to improve the efficiency of the generation of the compressed air.

In the transmission system we removed the compressed air energy from where we created to where we use it. The opportunity is primarily to eliminate irrecoverable pressure loss, because as we get pressure loss through the transmission system, the natural reaction is to go back to the supply side and raise the pressure – operating pressure – of the compressors.

Now, as far as the operating pressure of a compressor goes, the rule of thumb is two PSI increase equals 1% increase in kW of the compressor. So, if we have ten PSI drop or loss in the transmission system, that is 5% energy right there. So, pressure in a compressed air system is equal to energy, so what we'd like to do is operate the system at the lowest pressure that meets the needs of the demands in the system.

Now, on a manufacturing plant or production floor or processes that consume compressed air – we have a greater opportunity in most cases to reduce the consumption of air while still performing the operations as required and so these three components create the air more efficiently, eliminate irrecoverable pressure loss and optimize air consumption are the total energy reduction potential.

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We talked about block diagrams. This is a sample of a block diagram and you can see that it's very simple. We show the compressors. We've got an air dryer here, a filter, and a receiver tank. Maybe you might make a note here you know of the pipe size that's a 4 inch. We've got a loop here which represents the demand side of the system and sometimes you might make a note and say, "Oh, this is about 500 feet," and you might put a dimension on this or say a 1,000 feet. And then it might have a big air user over here, make a few notes like this but you can see that the block diagram is desired to remain very simple so that we can see the relative locations and relationships between different parts of the system.

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To prepare for a compressed air system assessment, we want to identify the key issues and opportunities that might exist in the system. How do we do that? Well, we put together block diagrams, we get information on the compressors. What's their flow and pressure rating, horse power, how many hours a year do they normally run and we come up with an estimate of annual energy use.

Now, why is it if we're going to do a study to estimate annual energy use or to baseline annual energy use, why do we need to create an estimate? Well, the estimate is going to guide in the scope of work because it's not cost effective to design a compressed air system assessment that might cost $30,000.00 or $40,000.00 to complete if the compressed air system is on consuming a $100,000.00 a year worth of electricity.

So, as we look at that initial estimate, it helps us decide what's going to be cost effective to do. Now, we mentioned that the waste of compressed air is a big opportunity in most systems. We said about 50% of the air that gets produced goes to waste and if we avoid compressing a cubic foot of air, we get back the full power that went into the compressor because if we avoid compressing the cubic foot of air, we avoid that 80% of loss that goes to heat.

So, potentially inappropriate uses of compressed air are something that we want to identify. What is a potentially inappropriate use of compressed air? It is something that we are doing with compressed air where there's a better alternative that's less energy intensive. The classic would be sweeping the floor. You know sweeping the floor with a compressed air is a lot more energy intensive to the compressed air system than sweeping the floor with a broom.

Now, sweeping a floor with a broom is maybe more energy intensive for the person doing the work, but we certainly would like them to be aware of the tremendous savings they give the compressed air system. Perceived high pressure applications every time something in an air system malfunctions it's always blamed on not having enough air pressure and very often that is the case, but the reason there is not enough pressure is because we've created very restrictive piping in the way we've connected up and we have a tremendous amount of irrecoverable pressure loss in getting the air to that tool or device that consumes it. So, is the high-pressure really a requirement or if we eliminated piping restrictions with the tool function at much lower pressure than it's believed to be required.

We have high volume intermittent applications. These are the air gulpers. These are the big things that take large amounts of air of the system for a short amount of time and those types of applications frequently upset the pressure profile and can cause problems. How do we take care of high volume intermittent applications? We add storage tanks and with the assessment, we can gather performance information both in terms of flow and pressure that will allow us to do engineered calculations to determine appropriate application of storage.

And then we also want to look at the big energy consumers in the system because if they consume a lot of compressed air, they consume a lot of energy and we should look at them for opportunities for improvement. The problems that we looked at earlier, low air pressure, water in the compressed air affect probably 70+ percent of all systems at one time of another.

And so, what we need to do is understand why those things are happening and come up with an efficient solution not just a solution that is quick and can easily be implemented. We need to treat the underline root cause problems. Ultimately, these things result in unreliable operation of a system and that's true unmanaged systems. Once we manage the system, we not only improve it's energy efficiency, but we also improve it's reliability.

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Now, identifying opportunities, this is an example of a block diagram where we've got four air compressors here and you'll notice we've got TA1 through TA4 and that would stand for Test Amperage 1, so it's indicating that we're going to measure the amperage of the four compressors and then we have an air receiver here with TP2 – that would be Test Pressure 2 air receiver up here with Test Pressure 1.

After the air dryer, we're going to do another Test Pressure 3 and so this is as elaborate as your block diagram and your measurement plan needs to be. It doesn't have to be a CAD drawn diagram with someone spends hours and hours doing. It can be a hand sketch on a piece of paper based on what you know about the system and then we pick the key points to measure the key performance perimeters. Now, one of the things we talked about is storage. One of the benefits of storage is the part load energy of a compressor and here we show the blue lines show a compressor, which is cycling very frequently. We've got this amount of time here and then this amount of time it's loaded here and it's unloaded here and you see that the red line with double the amount of storage with 2,000 gallons of storage versus 1,000 – the red line stretches out such that we spend a lot more time sitting down here in the unloaded condition.

And basically, as a result of that, the difference of the area of those curves is energy that we can save because when the shorter cycle, we don't spend this long time sitting here at the unloaded condition and so to optimize the energy performance, we want to have the compressor unload and spend a long time sitting down here at the low power level before it loads up again.

This is just one example of an opportunity that exists in many systems but our measurement plan needs to get us the data so that we can identify opportunities like we're showing here.

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So, we're going to look for an opportunity to produce air more efficiently, which is really going to focus primarily on our control strategy. We want to eliminate irrecoverable pressure loss in the transmission system and we do that by measuring and understanding the pressure profile and looking for opportunities to lower the system pressure and then the demand side we're going to look for the leakage, artificial demand, and inappropriate use of compressed air.

And throughout a few years of history with the Save Energy Now Program and the Industrial Assessment Program – Industrial Assessment Centers, which are University-based energy programs. The data shows that 75% of the identified possible savings in all those studies over about three year period come from demand side opportunities. Places where compressed air is being used in a way that there's perhaps a much better less energy intensive means of getting the end work done rather than using compressed air.

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We talk about control strategies. These are many different control strategies that you find on air compressors. Suction throttling without blowdown, suction throttling with blowdown, invariable displacement, load/no load, despairable speed control and all of these controls have some relationship of the percent of load capacity versus the percent of full-load power.

Now in the ideal world, we would like to see is as a one-to-one relationship, so if we're at 20% capacity, we'd like to be pulling 20% power and if we're at 60% capacity, we'd like to pull 60% power. You can see that the different types of control systems, how closely they come to this ideal compressor control, it varies significantly and so it's important to understand the control types of the various compressors that are at the site and be sure that we come up with a control strategy that optimizes the use of the existing compressors and the control strategy is really pretty simple.

First thing we want to do is turn off any air compressors that we don't need. We want them to shut down. The next thing is all the compressors that we are running, we want to run it full 100% capacity because that's where the air compressors operate most efficiently and then finally we have to understand that we usually have to have one compressor operating at some part low-capacity but if we were going to make a choice between operating a suction throttling compressor with no blowdown as the part-load compressor or perhaps the variable displacement compressor, which is designated by this green line here obviously we want to pick the variable displacement compressor as the one that would act as part low-capacity and we'd want the suction throttling compressor to operate at full-load capacity all the time.

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Now, I mentioned the rule of thumb earlier for compressed air systems and in a 100-PSI range, 2-PSI increase and discharge compressor, energy consumption increases by about 1% at the full load output of the machine. Raising the compressor discharge pressure also increases the air demand of the plant. If you think about if you have a hole in the pipe and you increase the amount of pressure that you apply to that hole, the amount of air flowing through the hole is also going to increase and so when we artificially raise the pressure of the system, we create an increase amount of air demand.
And it varies by plant but unregulated use could be as high as 30 to 50% of a total air demand of the plant. A 2-PSI increase in the header pressure could increase the air demand by as much as 1% and basically what we need to do is think about what percentage of the air demands in the plant are regulated. Now, obviously there's some amount of regulation at the end usage but in many plants – you know 60 or 70% of the air consumption is totally unregulated.

So, as we increase that pressure on those unregulated air demands, we end up with an increased amount of air consumption.

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Now, we need to understand the pressure profile of the system and this is what we would map out after making the measurements of the system. Basically, we start out describing the operating pressure profile from the supply side all the way over to demand side to the actual and end use consumption and to do that we take a group of pressure measurements.

On the block diagram earlier, we saw pressure measurements upstream and downstream of the compressed air driver. We would further make pressure measurements that would be represented by this Delta P for treatment here. Then we might make pressure measurements of the header pressure leaving the compressor room and then the pressure when it gets out far in the system on the demand side and then we have the piping that connects the header to the end use connection and this is where very often there could be a tremendous amount of pressure loss if the piping or holes are undersized, it's not at all that uncommon to find 30 or 40 PSI pressure loss right here at the end use connection.

And then what happens is the equipment doesn't perform properly. It's determined that you need more pressure and rather than do something about the restrictive piping, we simply go back to the supply side and raise the pressure of the compressor further. So, it's very important to measure and understand the pressure profile all throughout the entire system.

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Now, how does the pressure profile translate into possible savings? Well, the higher the pressure that we operate the compressor at, the more energy the compressor consumes. So, for example, variable speed drive, or VSD, compressors can give us a good energy savings in part because rather than having to pump up and unload and wait for the pressure to come down and pump up again, we simply set the VSD at a cast and target pressure such that, the red area under the curve represents energy savings by not constantly pumping the system up to higher pressure and then unloading and waiting for the pressure to fall.

At the same time, if we apply a flow control to maintain storage pressure, this differential here from 105 to 85 would be the amount of energy available in the storage tanks but if we control the system at the 85 PSI pressure, which is the blue area between the curves and represents savings and reduced artificial demand. That's the reduction of air flow that will occur because we're supplying the system at it's optimum pressure of 85 PSI rather than supplying 105 to the entire system. So, once we understand the pressure profile, we can determine where the opportunity for savings are and what is going to be a strategy to take advantage of those savings.

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And we get out in the facility and we start looking at things and this is real world photo. Apparently, these electricity cords were on the floor and so to get them up off the floor, they clamped a couple of U-Volts to this hose and hung rewires on them and look at the crimp and the restriction of that hose.

What do you suppose is going on at the tool at the other end of this hose and if that tool isn't operating correctly, what the solution is often times used is, "Well, let's set the compressor up another 10 PSI higher," and that's tremendously wasteful in terms of energy.

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Here's another good picture of hose – 100 of feets of hose where only 10 or 20 feet is required and every foot of that hose represents pressure loss in the system.

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So, irrecoverable pressure loss is a good opportunity and during the assessment, we want to look for opportunities where there's big restrictions in the system and where we can employ improved piping such that we can go back to the compressors and lower the pressure setting of the machines. Compressor air waste is made up of three primary components. Leakage and it's not all unusual for 25 to 30% of the air being wasted to leakage in some systems it can be easily be half or more. Artificial demand: artificial demand is the increased compressor air consumption of the system due to operating at higher than necessary operating pressures.

Any unregulated compressed air use has a 2% increase of air consumption for each 2 PSI increase and so we really need to understand that pressure profile and optimize it. Inappropriate use of compressed air. Blowing applications are notorious for inappropriate use of compressor air. Using compressed air to drive tools or motors where electric motors could be used, or driving a pump – diaphragm operated pumps are very often used and is there an electrical style pump that could better get the job done.

So, there's a lot of different potentially inappropriate usage of compressed air that might be improved upon.

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Leaving air open for drains. This is a pipe hanging off of header. It's about a 2 inch pipe or so and it's blowing a fair amount of air and the arrow here painting on the wall says, “Make sure you leave that open for drainage,” and then we have a little smiley face here. This is a valve in the upper right hand corner. This valve is actually designed to be a very efficient condensate drainage valve.

It's designed to drain condensate without consuming a lot of compressed air. But it's been mis-installed here where this line is suppose to be venting and blowing just a little bit of air, it's blowing wide open and the air and water just for blowing continuously out of there. On the end of this big large tank, don’t close the drain valve because we’ve got to drain the water.

I mean condensate drainage is important but there are valves that can be properly applied and maintained that can reliably drain the condensate from the system without wasting large amounts of compressed air.

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We talked about low-pressure blowers. Industry environment this has to be – I think at the plant that I did some work in – and they used air to clean themselves off, but you’ll notice that they’ve installed a little blower here and this is like your shop vac and turn the hose around so it blows and there's a hand held wand with a little nozzle on it right here and soon as you pick it up off the hook, the blower starts. You can clean yourself off and you hang it up and the blower shuts off.

This is not only much less energy intensive than using compressed air, it's also much safer. Here’s a case with air motors driving ink pumps and in fact years earlier – all this area was explosion proof requirement – because they used solvent based inks but for about five years prior to this picture being taken, they had switched over to water based latex ink and the explosion proof construction was no longer requirement, yet they have air motors consuming many times the energy of an electric motor still used to pump the ink.

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This is a lime tank with air sparging, which is another potentially inappropriate use of compressed air. The agitation you see going on here is being caused by a compressed air line. This pipe right here is a 3/4 inch pipe coming over and going down into some tubes in the tank. Now, this type of air sparging can easily be done with a low-pressure blower and the savings are quite remarkable.

Here’s a case where we have all of these little copper tubes blowing and cleaning chips off of a casting which is being machined and again these two large air delivery devices are called air cannons, they're hooked to a low pressure blower and they provide better blowing capability at about a fifth of the energy consumption and in addition to that, the better blowing pattern coming from the air cannons eliminated a lot of flying debris and problems they had in the production area with eye injuries from getting chips and debris in the eye.

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So, basically as we improve the compressor control, lower the system pressure and reduce the air demand, how does that affect the overall power in the system? Well, on this particular chart, what we have is – we have actually power – this is actual measurement of a system. We have the actually power on the Y axes – this is power – and then we have the air demand, the CFM – SCFM – on the X axes and remember we talked about the ideal compressor.

The ideal control for the system – the ideal control would create a relationship where the flow versus energy would follow this blue line as we start more and more Compressors. So, this would be if the controls were optimized that’s the relationship that we would have yet, what we’re noticing here is the actual data points – the red dots up here – are actually quite a ways away from that ideal line. So, if we were to improve the pressure control – compressor control system –

improving the compressor control would move all these data points closer to this ideal curve and this goes from 600 kW down to 400 kW.

So, that's a 200 kW savings right there if we had that control working in ideal fashion. Now, reducing the air demand is the third opportunity we talked about. Using less compressed air, what happens when we reduce the air demand? Well, when we reduce the air demand, what we do is, we move from the upper left portion of the curve down to the lower right. What's the difference there? That's a difference between 750 kW at the high end and 600 at the low end.

And so, by reducing the amount of air used in the production process even without optimizing the compressor control, we've got a tremendous potential savings and we also talked about lowering the system pressure. This is the 1% decrease of power per 2 PSI decrease in the discharge pressure and what that does is takes that whole ideal compressor curve that blue line and moves it down, and so there's our outcome of our three opportunities. Improved control: reduce the air demand and reduce the system pressure.

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Now, how do we identify the opportunities? What are the tools that we have available? Well, the tools that we have available are the LogTool and AIRMaster+. Now, in addition to that there's many more in-depth trainings that are available in addition to what we're going over today but the software tools are basically AIRMaster+ and LogTool.

AIRMaster+ let us measure the baseline performance and create a software model that the system analyzes the energy consumption then through various energy efficiency measures, things like reducing the system pressure, installing sequence controllers, increase in the amount of storage, getting rid of leakage or inappropriate use of compressed air. The software tool will calculate the energy benefit, the energy reduction of all these measures as it applies to the annual baseline that you measured and inputted it into the software tool.

LogTool is a software tool, which works both stand-alone and as a companion to AIRMaster+. In a stand-alone function, it provides charting and trending of information. It allows you to quickly get the data out of your data loggers and begin to look at it in chart form. It helps you assess the dynamics of the system and it controls response of the compressor. How are the compressors responding to changes that occur? It also helps you create daily system profiles and this is where it's a companion to AIRMaster+ because AIRMaster+ uses 24 hour time periods and typical days of operation to create the annual cost of operation to the system.

Now, what do we mean by all that. Well, if you have a varying production environment. Let's say that on a Saturday, there's a reduce amount of activity and on a Sunday there's minimal amount of activity, then you might end up with a system that has three data types. They would be a production day, it'd be a Saturday and then a Sunday and so what you would do is you would tell AIRMaster+ how many days each one of these different typical Day Types represents.

So, in a year period of time, we'd have five production days per week, one Saturday and one Sunday per week and that the AIRMaster+ software takes the baseline measurement that you do for each of those typical days and creates the software model with the baseline energy use and then the projections of savings based on the energy efficiency measures that we apply.

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Now, this is a screenshot of the main menu of the main AIRMaster+ tool and each one of the things in the left hand column represent that different inputs to software tool, the system information compressor and then this is the measured profile. That's where you do your measurement, and you input that profile then once this left hand column is all complete, you can apply different energy efficiency measures to evaluate what the savings projection are.

I will be going over the actual live tool and I have a demonstration that we'll do during a case study but I see a question about, what about plans that have multiple shifts. One of them might be a maintenance shift using less demand and that is exactly what we do when we work with the Day Types. The Day Types that we have here, we need to define those Day Types so if there is – for instance – on a Saturday a maintenance shift that takes place then the Saturday profile might be different from another production day where maintenance is not done to the same extent. Another case in point where you get different profile food processing plants have varying profiles because they may have every third day might be a sanitation day which has a different profile from other days of operation and then maybe every other Saturday is a maintenance day.

And so, you can have any number of different Day Types defined in AIRMaster+ and so long as you find a Day Type and you have a measured profile of the energy consumption for that Day Type, you can include those in your software model which would improve the accuracy of your model and your annual baseline cost and so forth.

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Now, if we look at this measured profile data, it's really the heart of the software tool and that involves measuring the power kW. You can do it using air-flow as percent capacity of the compressor, ACFM, cycle-time for load and unload machines or volts and amperage.

In the case study that we're going to show you, we've used volts and amperage. We did a spot check of the voltage actually, we just inputted the nominal voltage that motors were rated at and we data logged the amperage to create our 24 hour profiles and so with that information, you create the operating profile that is applied to each particular Day Type for the day of operation.

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Now, after we input that measured profile, we can pull various charts and graphs in AIRMaster+ and this particular one represents a kW, so this might be the actual measured kW of a typical Monday through Friday for these three air compressors.

Now, once we measure that profile, and we've defined the performance of the air compressors, the software can express that measurement in terms of air flow as well. So, what we see in – oh, we haven't got it in here, I thought we had it in here – but we'll second it in the life tool. If I click on this radio button here called air-flow, what it will do is it would convert this from power to CFM and it would show us to relative amount of air-flow from each air compressor.

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Now, once we have the baseline data in place and we have this measured performance, now we can look at energy efficiency measures, reducing leaks and improve end use efficiency, which improved end use efficiency might be resolving inappropriate use. One of the classic examples is using high-pressure compressed air to blow water off the product and every one knows that when you go the car wash at the end of the automatic car wash, they have huge blowers that blow the water off your car. Yet, in an industrial setting, rather than put in blowers and fans, we often times use high-pressure compressed air.

So, improving end use efficiency might be what we're going to for what used to be a 100 CFM worth of blowing and we're going to replace it with a 3/4 kW blower and AIRMaster+ will calculate the benefit of all those energy efficiency measures. When you reduce system pressure, we talked about the benefit of that and then there's a couple of different control things to adjust. We can use unloading controls, adjust cascade set points, put in an automatic sequencer. A number of different control scenarios. Also, reduce run time in some instances maybe you could just shut the compressor off overnight and you would model that in the software with reduce run time.

And we talked about adding receiver volumes to the system, so once you input these various measures into the software model, it calculates energy savings in terms of kW-hours, energy savings in terms of dollars per year. It will calculate the kW demand savings if you input that in your electrical rate structure and there's a place to put in the estimated install cost in which case it will get calculated simple payback.

So, there's a good reliable outcome of improvement projections based on entering a particular scenario of changes in the system.

Darryl: Tom? Yes, excuse me, when you hear the pause point, we've got a couple of questions out there concerning logging data.

Tom: Okay, yep let me hit that in just a second before I go on to LogTool, that'll be a good place to do it.

Darryl: Good enough, thank you.

Tom: So, as we develop the model, we have these scenarios that we can create and it's important to understand that in a compressed air system what you do in terms of adjusting the pressure effects many things in the system. It effects how the control scenario operates. It effects how much consumption there is by reducing artificial demand in the system and in an air system, the different parts of the system are very interactive and so in the software tool, you can create any number of different energy efficiency scenarios so you might have a whole laundry list of things that represent your possible savings, all the different measures, but then you might say, "well, gee what if we only do these four or five things instead of doing all of them, what would our savings be," so you can create an unlimited number of scenario within the software tools.

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Now, the next thing we're going to do is talk about LogTool and LogTool is a tool. It's a public domain tool. It can be downloaded from the Web site at the Department of Energy. It is actually, the software code itself, is maintained by SBW Consulting and it's also available from their Web site as well and it allows you to import data from different types of data loggers and display plots and trends and it helps you configure the Day Types that we talked about and it does many things to assist you in the analysis of the performance data.

So, let me just take a look here at the questions that we have related to data logging. One of them, I guess would be the plant with multiple shifts and have shifts that use different amounts of air, and certainly you would want to measure the performance of the system under different normal operating scenario. So, if you have a maintenance day or maintenance shift or sanitation day and so forth, you'd probably want to actually measure during those different times and we'll see how LogTool will show us the different things that happen in the system.

Positive displacement compressors versus centrifugal, and when they should be applied and how does it affect the analysis is another question that we have here. The answer to that is different compressors lend themselves to better and different types of operations. For example, centrifugal air compressors are best operated constantly at 100% capacity. They do have a small control range where they can efficiently operate maybe from a 100 down to 80% of full load capacity but below they become very inefficient because typically what they do is blow the air off the atmosphere after you spend all the energy to compress it.

Piston compressors positive displacement machines on the other hand, maybe don't have quite the full load efficiency of a well designed centrifugal but they very closely approach that ideal curve in their part-load performance and let me just go over here and let me pull up a journal that I can draw on.

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If you recall, what we had was percent capacity from 0 to 100% and we have percent kW from 0 to 100% and if we were to compare a recip compressor, reciprocating. A reciprocating compressor when it's unloading might operate at 20% of full load power. When it's fully loaded it operates at 100% of full load power and many of the big recips have got multiple step control, so there might be a 75% point. There might be a 50% point and a 25% point and what you would find is that at 50% capacity a recip might be functioning at 53 or 54% of full load power.

Whereas, a centrifugal compressor at 100% capacity it still pulls 100% power and a centrifugal might be slightly more than a recip at that point. But what's it's going to do is, it's going to come down here and in reasonable fashion where at 75% capacity we might be pulling 78% of full load power but at this point in time it's going to go blow off and it's going to pull that same 78% of power regardless of how much air is going into the system.

And so, what we've got here is this relationship of the reciprocating compressor operating at part load versus the centrifugal, and remember our ideal compressor down here is going from 0 to 100%. This is the ideal and so the centrifugal could potentially waste all this amount of energy if we were to apply it and use it at the very low-end range of its capacity. So, we really need to assess how we are going to use the compressors and how we can best use them to our advantage.

Another question is, what kind of intervals do you record amp and pressure readings in the system and that's a very good question to create the profile.

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And let me say this, if we have power on the X axes – excuse me – time on the X axes – time and we have power on the Y axes, when we're at a 100% capacity, the machine pulls 100% power and in the case of lubricant injected rotary screw compressors, when the machine unloads it pulls about 30% on a full-load power but at the time it unloads the power doesn't immediately drop like this down to the unload.

We looked at those curves earlier where the power drops all the time like this and then it uploads and it loads back up. It loads up pretty quick and then basically what happens is the pressure goes up. The power goes up a little bit and then it unloads again and so we could get this relatively large change in power as the compressor loads and unloads. So, let's say that this is a period of one minute that we're showing right here.

If we set our data logger to take one reading a minute, then will it take the reading at this point or will it take it at that point or will it take it over here. You know, what is the power at that instant that you are looking at it and then you are not going to look at it for a minute later. Well, in the meantime, the compressor might have loaded and unloaded ten times and you would never capture that. So, basically what we take a look at is doing a higher sampling rate, such that we're taking readings, and basically we take readings that produce slices of time, and then we integrate readings over time so that we capture these changes that occur.

Now, the best method of determining what time base is appropriate in this particular instance would be to look at the duration of the load cycle which is up to here – the load cycle – and the duration of the unload cycle. So, if this is a minute worth of time and we were going to – say these were all equal – so, this would be 15 seconds. This would be 15 seconds. This would be 15 seconds. No, that would be half a minute. Four times 15, okay, so this would be 15 seconds.

If our time base – in other words – the shortest interval of time that we're trying to capture is 15 seconds, we would want to have at least five to ten data points during that time. So, if we had five data points that would be one data point every three seconds. So, it'd be 3 seconds per data point. If we were going to capture ten slices – remember we're talking about these slices over here – if we're going to capture ten slices during that period of time, we'd be talking one data point every 1.5 seconds.

So, we'd have to have 1.5 seconds per data point. So, that's how you would analyze it, and it really again, your time interval that you need to record depends on the dynamics of the system and what's actually happening there. So, that's a very good question. You can see that you have a big potential error if you don't understand a little bit about the dynamics of what's going on as you determine what your data density is going to be.

Now, there's another question up here about the advantage of a centrifugal limited operated efficiency range and yeah, the advantage of this operating range that we talked about before on the centrifugal going back to here.

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The advantage of operating in this very narrow band up here is the centrifugals run very reliably and if you maintain good operating maintenance, they can run for extended periods of time without even shutting down. They can run for extended periods of time without very little maintenance and as long as your in that relatively narrow window, they are very efficient.

I have one client with a centrifugal compressor that ran five years with almost no shut-down time. They actually have that machine set up so that they can change the oil filters and change the oil on the fly while the machine is running and so that's probably the big benefit of centrifugal compressors. Also, in terms of first cost, a centrifugal compressor get bigger and bigger, their first cost becomes more and more attractive.

So, if you are going to have a machine that's a 3,000 horsepower machine, centrifugal compressors really become very attractive in those very large machines. Anther question came up about averaging time intervals.

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And for certain averaging time intervals is a good thing to do.

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Let me just jump out here to another clean sheet and let's talk briefly about that curve – let's just say we got anything going on here – and we've determined that we need to have some time intervals sliced like this that we're going to use to be able to integrate and capture this as an average.

Well, if we're going to take these readings that say, pretty quick – let's say we go a 100 milliseconds per reading, we probably don't want to save the data at a 100 milliseconds but what we could do is we could average several 100 readings and we could say one data point per minute and then our data density is one reading a minute but it obviously is a much more accurate result than simply looking at it one point in time and saying, "That's what it did for the whole minute."

So, over sampling with data averaging is certainly a good strategy. Now, there are two types of information that you want to get when you take your baseline data though. One is information about the trends of what's happening, and data averaging is certainly good in that respect, but you might want also want to capture the dynamic response of the system, in other words, this big air gulper pulls air out the system for 15 seconds, how does the compressor controls respond to that and so that would be a dynamic analysis and would require a different data density.

So, you need to think about how your going to use the information to ultimately determine what is the data interval that you actually want to have but using a data logger that has over sampling capability, one that slicing it into very narrow time slithers and take readings very quickly is a good strategy whether your gathering trend data or dynamic data either one.

So, again you need to know a little bit about the dynamics of the system and what you are contemplating doing, what your data and when your sampling waits and averaging time intervals and all that data related stuff. I think that's hopefully addressed some of the questions that are up there that I see at this point and maybe what we'll do now is jump back into the prepared presentation and we'll talk about LogTool because …

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Darryl: One last thing, just flipped up and the question was are you categorizing rotary screw compressor that's centrifugal or recip?

Tom: Okay, rotary screw compressors – there's' two basic categories of compressors – and let me just jump back to many journals here.

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There's two basic categories of compressors. There are positive displacement and then are dynamic, and the classic example of the positive displacement compressor is the bicycle pump, right? We've got a cavity here. We've got a plunger. We've got a rod connected to the plunger and what I do is, I raise the plunger up and I suck up air in and I trap it inside this volume and then I squish it and as I squish it, the pressure goes up. Now, there are many types of air compressors that are positive displacement compressors, obviously piston compressors are positive displacement compressors. Rotary screw compressors are also positive displacement compressors because what happens is in a rotary screw compressors, you've got a male rotor with lobes on it like this and a female adjacent to it has mating flutes and I could try to draw this thing in 3D, the male lobe might come back with a profile like this and the female flute would have another profile back like that and as the two match together what happens is the volume space between the two progressively gets to be smaller and smaller as the two mesh with each other.

I apologize, I don't have a good slide of that in the presentation but rotary screw compressors are in fact positive displacement machines, they trap the air in the volume in the female flute and as the male rotor progressively engages the female flute they decrease the volume and increase the pressure. Scroll compressors are also positive displacement compressors. Vain compressors, rotary vain compressors are positive displacement machines. Centrifugal compressors are dynamic machines.

Dynamically, we have a impeller blades on it and what happens is, we pull air into the inlet and then this impeller might be rotating at very high RPMs – say 50,000 to 80,000 RPM and what happens to the air that enters the impeller is it gets swung outward and when it comes off the tip of the impeller. Its velocity factor is extremely high. It's traveling essentially at the tip speed of that impeller, so when we've in parted a lot of velocity energy to the air but the pressure, if you look at the pressure at the inlet and you look at the pressure at the tip, they are almost the same.

There's a slight pressure increase. What happens in the next part of the Centrifugal compressor called, "the diffuser and the collector." In the Ddffuser and the collector selection, the velocity is slow and the velocity energy is recovered as pressure energy and then it goes through an inner cooler and goes into another impeller – maybe a second stage and third stage of compression.

So, the characteristics of dynamic compression and positive displacement compressors are very different, hence the different performance curves and why the centrifugal machine you get that very narrow turn down band versus a rotary screw which can operate across a much wider range of performance. So, hopefully that addresses that question.

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And we'll jump back into the presentation and talk a little bit about LogTool. Now, very often when I'm out on a job, I'll program many data loggers. My data logger samples at 100 millisecond rate and then I'll program it to store data points maybe once every 6 seconds or so and I end up with 14,400 data points per channel per day.

And so if I do a weeks work of readings and I'm measuring the data on five different air compressor and we've got eight or ten pressure measurement locations, you can see this becomes a tremendous amount of numbers and looking at columns and numbers tells you nothing about what's going on, you need to get that resolved into charts and graphs and things where you can see what's happening and that's where LogTool comes in.

LogTool will pretty easily suck the data off of almost any kind of data logger you have and allow you to begin to manipulate it in various forms.

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This is the import screen for LogTool and you see here that there's a section here that says select the logger type addiction then you pull this pull-down list and there's a list of several different data loggers that are very common.

There's also another data logger type called an "unknown data logger," and with unknown data loggers, you can take any file that's in a structured format be it a text file or a CSV file and it is something that you can define a structure for, LogTool can then recognize that structure and pull the data in, so if you've got a billing management system like – I've worked with Johnson Medicist from Johnson Controls or you got a system called, "Pie," or "Wonder Wear."

There's a whole variety of them out there. If you can get the data into CSV formatted text file, you can pull that into LogTool and we'll show that a little bit later in the actual tool itself.

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And again, what I said before, looking at the data in graph form is much more informative then looking at a simple list of numbers and this is a static display of a graph. Now, if this was a tool, which we'll see in a minute.

You can actually draw a box around the section of data with the tool – let me just change the ink color here – if we go back to here – oops, wrong way – you can draw a box around the portion of the data and it'll zoom in and then you could zoom in further and further and we'll see that in the live tool here in a little bit.

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We talked about creating Day Types and we talked about the fact that there are maybe a maintenance day or wash down day. Well, LogTool takes those 14,400 data points per day and it automatically calculates hourly averages for all those data points. Everyone of these little points here be it a blue circle or green square or a pink triangle, everyone of those data points is an hour average of the underline data.

And what we're comparing is kW, the hourly average kW versus the hour of the day and what we see here, and this particular tracing could be maybe three or four different trends. What are they? Well, certainly we seem to have one trend that's just flat like this, right? So, this would be Day Type 1 and then if you take a look at it – let me just change over here to green – if we take the green ink, we say, "Okay, we've got this little hump here in the center like this," so that would be Day Type Number 2 and then if I change to this orange color here, we got one that humps way up in the middle like this and comes down, so this would be Day Type Number 3.

And the question is, "Okay, would you just call it quits at 3 Day Types or would you also want to take this little chunk in the middle." We got some days that are kind of in the middle, would you want to toss those into the bucket with a new Day Type of Number 4. But you could see that regardless of what's going on in the plant whether it's washed down or maintenance or just another normal day of production, it's going to be reflected in the change in air consumption and is going to be reflected in the hourly kW performance and once you put it in LogTool it's very easy to operate and select Day Types.

Now, in this particular case, we selected Wednesday, Thursday, Friday production day. We selected down day as a Day Type and a Monday, Tuesday production day.

So, we broke this into three basic Day Types and - I apologize, I just hit a button on the computer that I didn't want to hit. Let me get it back here, okay now we're back. So, we broke it into three Day Types, we didn't make a fourth one out of it and what's interesting is, you see this particular day here is a Friday, this Friday was a down day but this Friday here was a Wednesday, Thursday, Friday production day.

And so, even though we're calling it a Friday production, here's a Friday that was actually a down day. So, you can call the days whatever you want to call them, the key is to look for the similar operating characteristics. Now, once we get all this data – we define our Day Types – you see over here, we create a numeric hourly average and get that into the AIRMaster+ tool.

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We simply pasted it into an Excel spreadsheet and then we highlight a section of the data and we can move it from there into AIRMaster+.

And in the case study, I'm going to actually do a little demonstration of that for you so as we move into the next section here and so what we're going to do is look at a case study.

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We're going to talk about the normal process, and pre-exception information; we'll take a look at the block diagrams and some of the things that were gathered, some of the plant background information, the system in plant layout, what kind of issues they we are having, and then we'll jump into the software tool and actually do a few things with AIRMaster+ and LogTool.

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So, this particular plant produces cutting edge products made from synthetic materials and they add functional advantage compared to traditional materials. The plant is a highly automated manufacturing process and what they do is they custom blend resends to customer's orders construed and compression mode sheets and do finishing operations that are very customized for their end users.

They have highly engineered building materials and have a lot of very proprietary blending scenarios that they go through. The manufacturing is streamline efficient and they actually have integration between the ordering system and the production systems and they run many, many different products with very frequent change over intervals.

Presently, at the time of the assessment, they were running at 40% of their normal capacity which is considerably down from where they normally operate. They have four production buildings and they have eight compressors applying three different air systems. In other words, the production buildings through – of the four production buildings – two of them have combiner systems and the other two are independent.

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In a system engineering process, what we will need to focus on from very early in the assessment phase are what are the needs of the stakeholders and that basically hinges on what is the system functionality and where is the system failing in defunction in a manner desired.

So, what we want to do is understand the point of use – as it supports critical functions. We want to have on a short list correcting problems that they are currently having. We want to eliminate wasteful practices. We want to have a strategy to maintain an energy balance between compressed air supply and demand and we want to optimize the compressor control.

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Now, this is our site, basically as we said, there's four buildings, this is a main production building. These are the two building for the combined air system, which are production building and then they have the blending building back here which is on another separate compressed air system.

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And the block diagram, again, very simple diagram showing the major components. These are the four compressors that are located in Building 1, and I believe and they have amperage measurements here, pressure upstream and downstream of the dryer, and pressure upstream of this dryer. This pressure downstream is going to be about the same. Then they had their presses, saws and extruders out here, and the presses in particular are somewhat pressure critical, so we pick a pressure point out there near the more critical in-use equipment.

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What are some of the things that they talked about? Well, overall they are saying that they have a 25 horsepower machine that’s not in very good shape and they can run that except for when they run off the extruders in particular, and then they need a much greater amount of air. They normally try to run the smallest compressor they can and that’s certainly is good practice.

There's little production in the building and presses one and four run Monday through Thursday, and the saw only runs on second shift Monday to Friday. The Extruder 2 only runs a few times a year and that’s the big air consumer and so here they have a relatively large air compressor that much of the time is not nearly utilizing it's capacity.

They had a 125 horsepower compressor which was way to big and they at least knocked it back to 75 horsepower, but still that does not maintain a good supply and demand and balance except for the occasional times when Extruder Number 2 is running along with everything else.

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So, this is typical of the type of information that we would gather ahead of time and I don’t know – we were going to try to send out this PDF and I know there was some e-mailing issues whether it went out or not, I don’t know, but this is a PDF package that we can get to everybody of the plant background.

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And basically, it reviews the kind of things that we were talking about, the kind of production that they have. What we do with system engineering, site plan and block diagrams and here are the test points that we looked at in Building Number 1. We had a similar diagram for Building Number 2 and 3. Building Number 2 and 3 were the ones with the combined system. Their cross-tied here and there's actually Compressor 2, which is located in Building 3 and Compressor 1 was located in Building 2. So, Building 2 is kind of a front part whereas Building 3 is the back part.

And then there was air receiver where the cross connects to Building 4, which if you remember in the back of the site – let me get back to the site plan.

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At the back of the site, we have Building 4 and there was an airline running between Building 3 and 4.

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But it is normally closed.

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And then if we go back to the block diagrams, here's our Building 4 block diagram including two air compressors, again amperage on each compressor, pressure at each discharge, pressure downstream of the treatment equipment and that's about 250 feet over the blending where we put in Test Pressure 15 and this is the line that's going out to the side loads which have desk dryers and we got pressure upstream and downstream because they have to see what pressure is being delivered to the Cylo.

And again, when you are organizing an assessment, drawing out all these block diagrams and everything else might sound like a daunting task but it really is not. This is as complex as they need to be and again they could be hand sketched just like we see here. It doesn't have to be a hurculeon effort to pull these things together. Now, this is some more information that we just looked at for Building 1.

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We also send out informational questionnaires to the other buildings and the Building 2 and 3 low compressor – low pressure and they had 250 horsepower, a 75 and a 60.

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They replaced it, they added a 200 horsepower to there, which was the big machine now and it's located in Building 3. So, those are some of the historical problems and what they did to resolve them and a lot of air consumption and the Cylos, they had a lot of leakage out there, they had actually taken care of that and then it was in that result the compressor that they put in the Cylo building that really became too big for it's use. But then you had to ask yourself, what is the need and the benefit of really combining these things into a single system, versus maintaining these three separate systems and that certainly became the objective of the analysis.

So, let me now jump over to the actual tools themselves and what I want to do first is jump over to LogTool - which I don't see that I've got that running, let me get LogTool running here.

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You start up LogTool and this is your opening screen and what I'm going to do is open an existing database and we have this database for LogTool and Version 1 and this is the data from measuring all the different compressor amperages.

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And it's really good at this point because, we can look at the trend information. Now, you'll notice here that for the trend data, I'm looking at Compressor 2, 5, 6, 7 and 8 and the reason is during the assessment those were the only compressors that were running. If I want to look at the raw data, then I can click on this data button, then there's all the different numbers that were recorded. And so, this was a 6 second interval of time and it went from September 25 through October 1.

So, this is a fair amount of data here. Looking at the numbers is not very meaningful, so instead let's look at the actually amperage readings themselves. So, I've checked off the Compressors that I want to look at. I hit the trend button and what it does is it generates a graph of all of the data. Now, granted there's a lot of data here. I've got a fast computer and it still takes a little bit of time to generate the chart but it will pop up here in just a second.

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So, what we see here is the blue line is Compressor 8. This lighter blue line is 7. The green line is 6. The orange colored line is 5 and the red line is number 2 and I said that we could drill down into the data. Let's drill down into the data here where we got a lot of compressors running and as we do that, look at the phenomenon that we see.

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The amperage is going up and down on compressor number 8, so it's loading and unloading that's the one in Building 4.

Compressor 2 and 3 that are both located in a common system between Building 2 and 3 – that's Compressor 1 and 2 rather – those machines are also going up and down. Here's Compressor 2 and the amperage is going up and down as the machine loads and unloads and at the same time look at what's happening down here with Compressor Number 1 in Building 2. It's actually starting up, delivering maybe a short amount of air and then it's running idle and shutting off and we talk about the opportunity to improve compressor control. Now, obviously the best way to run an air compressor is with a shut off and if your not going to have it shut off, the next best way to run it is full load.

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Well, look at what's happening in our control scenario here. We've got one, two, three, and four compressors all operating a part load. So much for base loading the machine and trending with another one and shutting everything else off. So, that's one of the disadvantages of the system being split because the Building 1 system up here – the red line – is isolated from Building 2 and 3 which is isolated from Building 4.

So, these things are actually working as three independent little islands. But even where we are connected between Building 2 and 3 look at what happens. The compressors - main compressor in Building 3 loads up, it unloads, the pressure comes down here and the pressure drops for awhile and all of a sudden the compressor in Building 1 decides, "I better start up." It starts up, barely gets running and then the other compressor loads and then this compressor simply it's there doing nothing until the timer times out and then it shuts off and no sooner than it gets shut off but the cycle repeats itself.

Tremendously inefficient way to operate a system and remember I said that when your doing your data – your setting your data intervals – and your doing your over sampling and your data rates you want to look at both trend and dynamic data. Well, this is the dynamic of the system that gets revealed that 6 second data interval. Even though we're sampling it a 100 millisecond rate. So, if all we had was the trend information available with one reading a minute or something that we average to, we wouldn't have the luxury to seeing this control action that's taking place which represents a big opportunity for savings in this system. So, that's the benefit of the trend information.

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Now, that's just looking at amperage.

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Now, we also have pressure data and let me just start Excel here and let me go to the file, open – over here – and it's actually a kind of separated variable file and let's look at the amperage file.

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This is all of the amperage readings that we were just looking at that have already been imported into LogTools and this would be imported using the unknown logger type and basically what we have is, we have our date and time in the A and B columns and then we have our amperage for all the compressors and you can see here the different times when the measurements were started and we have all the amp readings for the machines. Now, that data has already been loaded into AIRMaster+ so, or into LogTools – so I don't care about that – let me just get rid of that – but let's open up the pressure data because the pressure data is not in that LogTool file that I opened yet.

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Remember all those test pressure points that we talked about? Well, all those test pressure points are here in this file and you'll see here we start to pick up some pressure data here and there we've got all the pressure transducers installed and running and so here we've got again pressure readings every 6 seconds, so we can see what's going on in the system.

And again it's from the 25th of September until the 1st of October and so – let me close this and show you how we pull this in LogTool.

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We go over to LogTool here – this is what we were looking at trend information earlier – and we say, "import logger data," and then the logger file type is going to be unknown software because it was just a structured CSV file.

I select a data file and - I've got to go back to my directory where we were in here – and I have a data for LogTool.csv. I click on that and I hit open and then I get an error. Well, nothing is ever totally without flaws.

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Let me open that back up. LogTool. Pressure. Okay, one more time. Import logger data. Unknown logger software. Select Logger files. Oops, I don't want to do that. Open.

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And now what it's doing is, it's pulling in all of those columns and rows of data and here are all of our pressure channels. So, we go from TP 1 to TP 15 and each one of those channels is a pressure channel and each one of those is 14,400 data points per day from the 25th of September until the 1st of October. So, I'm here to tell you what is – as long as that took it was really fast. Now, you see here that it gives us our start and end period.

It says it's 6 second data interval. It says the file status is okay, so all the data points came in and all I do now is say, "import check to channels," and what it's going to do is, it's going to import all that data into a file.

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Now, if you recall, the anomaly that we had between Compressor 2 in Building 1 and Compressor 3 in Building 2 and so – or no – it was Compressor 1 in Building 2 and Compressor 2 in Building 3. So, it was these two compressors here.

So, let me get rid of the other compressors amperage data and let's just look at those compressors and how they're responding versus the wet receiver pressure in Building 2. So, now on my trend chart I'm going to have amperage on the Y1 axes and pressure on the Y2 axes and I hit trend and it's going to open up a chart that’s not going to be busy with those compressors in the other buildings because these are just going to be the compressors in Building 2 and 3.

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And now what I can do is, I can zoom into this data here and I can get in here in ways and – let me zoom in just a little bit more.

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And we’ve got – put some grid lines on here – and we’ve got amperage over here on Y1 axes and pressure on Y2. And the soft tool pattern at the top is the pressure and the kind of brown line is the amperage of Compressor 2 and the red line is at Compressor 1 that keeps kicking on and off and if we zoom in here even tighter, we can see that the pressure is falling as the machine unloads and then right here the pressure has gotten down low enough. Now, the pressure is at 98 PSI and low and behold that triggers Compressor Number 1 in the red line to start and then it falls just a little bit more to 93.7 and then Compressor Number 2 loads.

So, what we need to do here is we need to either raise the load point pressure of Compressor Number 2 and get it to load quicker so the Compressor Number 1 doesn’t start or we need to lower the starting pressure of Compressor Number 1 so it stays off unless it's really needed. So, here’s a case in point with just a simple adjustment to the controls and the compressors. We should be able to create a pretty good energy savings.

Now, we’ve gotten this all out of the data in LogTool and looking at these trend charts.

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Now, the next thing I want to do is talk about creating the Day Types. So, if we check off the compressors that we’re running which were two and then TA 5, 6, 7 and 8. Those are the ones that were actually running and I've come over here to the Day Type column now and I check off those machines that I want to trend and I hit Day Type and it opens up and there's that real live chart that we were looking at before.

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Now, if we take a look at this, when you click on a day over here – see how it lights up in red – well, that Friday was only a partial days worth of data, we didn’t have all the data loggers hooked up. Saturday was a full day of reading as was Sunday. So, here we go Saturday and Sunday look pretty similar don’t they?

And then, Monday starts a out a lot like Saturday and Sunday but then production starts up so then Monday’s a kind of a unique Day Type unto itself and Tuesday is a real full production day and then Wednesday is much like Tuesday and then it drops off and the reasons Wednesday drops off is that was the end of the data. That was when we unhooked the data loggers. So, it really looks to me in this system that there's a Saturday, Sunday Day Type and then Monday is a day unto itself and then Tuesday is a production Day Type and then Friday falls off here and presumably Friday would have been up here earlier so probably there's a Friday Day Type as well.

So, you can see how quickly LogTool is taking all of those column numbers and now we've got our early averages and I can look at the Day Types. Now in this particular case, the client wanted it to be modeled as if every day was a production day because that was what their normal operation was – remember I said they only run at 40% capacity – and they said, "Hey we don't care business is going to get back and we want to do the analysis as if we're running flat out."

So, you'll notice here, we've only created one Day Type called a "Production Day," and so with that Day Type created, I can come over here and say, "Create Day Type Profiles," and what it does is it now takes all those data points that represent that Tuesday of operation and it takes it for each air compressor and it extends it out into hourly averages all the way out through the whole time.

And you'll notice it does it for each of the air compressors. Now, I'm going to close out of this LogTool file and I'm going to open up another one, which is more well prepared for what we're going to do next.

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Let me just open up this one called, "Final," and what the difference here is I go to my Day Type and you'll notice – oh, I still got all the different compressor types – interesting.

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Okay, so there's our Day Types that we have defined. Now, what I'm going to do is leave LogTool for a second and now I'm going to go to the AIRMaster+ software and I've got an AIRMaster+ file open and it's short Compressor Number 8.

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I've defined the compressors that are running but I don't have Compressor Number 8 in here because I wanted to show you how you add a compressor.

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Basically, what you do is you open up to the compressor inventory and you click on new and that throws us over to a catalog of compressors with typical performance. So, we don't have to re-invent the wheel every time we have a new compressor. What we do is, we come in here and we say, "Okay, I want to select a machine which is load/unload type of control and I want to select a machine that is a 150 horsepower or 110 kW," and let me just search on that and let me see what comes up and you'll notice that we come up with a number of 150 horsepower air compressors here and load/unload type and we've got one here which is 642 CFM and a 125 PSI working pressure and that one happens to be very close to the one that was actually in the plant. So, what I do is I highlight that and I say, "Select," and it now has imported that back into my inventory of compressor.

Now, this compressor is in Building 4 and it's Compressor Number 2 and we identify it as GA110 and the description for this compressor is going to be Atlas Copco GA110 and it's amperage measurements was Test Amperage Number 8 so I'm going to make a note of that there. Now, if you take a look, we've got performance tabs over here that show the kW and the air flow and the discharge pressure and the machine and everything, we can look at the performance profile which is that percent capacity versus full load power curve and that's the way of the relationship of this compressor.

So, it's pretty good part load compressor using that type of control. We're not at the ideal line but pretty close and so now I have – I save that – and I have that compressor now added to my inventory and really setting up the model is just that easy to pull in all the different types of compressors. Now, what we do is we come to the profile module. Well, you'll notice here that the compressor that I just added is turned off and all the profile data here is zeros.

Well, that's because we haven't imported the profile information as of yet. The profile information – remember we created it on LogTool but we haven't got into AIRMaster+ – so the first thing we need to do is, edit this and we come in and we need to turn this compressor on. So, I can just say, "copy previous column," and now I've got all the compressors turned on for all the 24 hours. But you'll notice my profile down here, which is volts and amps is still all equal to zero.

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Well, this is where we go back to LogTool now and what we do is we go to our Day Type and we come over here and we create a system Day Type profiles and then we copy into clipboard. Now, that profile for that Tuesday, those hourly averages have now been copied to the Windows clipboard and I come over to a new blank worksheet and I can paste all that data into this file.

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But remember, we said that Compressor Number 1 – this compressor – Number 3 and Compressor Number 4, those compressors weren't running and so I haven't got them entered in AIRMaster+, so what I'm going to do right now is delete that one and I'm going to delete these two rows and now we've got TA2, TA5, TA6, TA7, TA8 which is exactly the order of compressors that we have here. We have the TA2, 5, 6, 7 and 8. So, now I've got the same list of compressors in both places in my Excel spreadsheet and in my AIRMaster+ profile module. But, you'll notice that we're using volts and amps and in my Excel spreadsheet, I only have the amperages that were measured.

So, what I've done is I've created a form in Excel, which is – let me open and Excel file – profile form for Tuesday.

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If I open up that profile form, you'll notice that I got a shaded area up here and down here I've got another area that represents volts and amperage and what I can do now is come into this file and I can copy the data I've got here and I come back into my form that I've created and hit paste and now you see it's populated that and it's calculated these averages in here.
Now, apparently I had this form set up to take the raw data right out of LogTool. So, let me go back here to LogTool and go to the Day Types and let me copy the whole thing to clipboard and I'll come back to my form again and hit paste and now you see I actually created this form so it deletes the compressors that aren't running right here.

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Now, this segment of data here for the compressors that are actually running, this 24 hours of data is exactly what I have in AIRMaster+ so I can select copy here and I can go back to AIRMaster+ and I got to my profile module and I hit paste from clipboard and there come my volts and amps for all those days of operations and that whole video is now populated with the appropriate information.

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So, I can save that and now I go to my totals and there's my annual operating cost for the system. It's totaled it all up and I go to the profile summary. I can graph it here and this is very interesting summary here because you remember that one compressor that was running and doing very little because it was starting up just before the other one loaded, that was this green compressor right here and it's fighting with the yellow one.

So, basically if you look there's a little tiny sliver of green here, which is the air flow that machine is contributing to the system. How much power are we consuming to get that little bit of air, look at that. There's all that wasteful power of that green compressor that keeps kicking on and off and we should have a control strategy that keeps it off.

So, we've got our profile information in here and energy efficiency measures and remember I said, "If we came up with a better cascade, a better control strategy," well, there it is.

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If we combine the buildings together all into one system and we come up with a better control strategy, here's $45,000.00 a year worth of savings and that's $45,000.00 worth of savings on a system that we're spending $149,000.00 a year to run. That's a pretty big hit.

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And then within the energy efficiency measures, we have other things like reducing air leaks, improve end-use efficiency where we had a blowing application and what we're going to do is put in a 6 kW blower in place of that blowing application. All these different things and they all show up on the savings summary and they show how much savings per year we can get.

Now, this particular one what I did was I shifted the savings from a cascade to a sequencer. I said, "Okay, what if we put in an automatic sequencer instead." Well, the automatic sequencer negates the benefit of the cascade control because both those measures affect the way you control the system but either one has a benefit of $45,000.00.

Now, let me just open up a different version of this same AIRMaster+ file which is the one that was completed and then we go to the energy efficiency measures here and there we see incremental savings now of $41,000.00 for the cascade and a additional $8,400.00 savings for the sequencer. So, this kind of shows them in progression.

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Now, you get to the savings summary and you can copy that to the clipboard to and then you can come into Excel and open up a new workbook and hit paste and now here's all of our summary information that we just looked at and you've got it out in Excel or you can work with it,

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Or if you simply want to produce a report, you come back to AIRMaster+ to the energy efficiency measures and you go to file, print and print the savings summary and it'll preview and there's the savings summary printed out and you can print it to a printer or PDF or whatever you want to do from there.

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So, and there's tons and tons of reports. We had that profile report. We can come over here and we can do file, print on the profile and let's do all Day Types preview it and here's the volts and amps of each of the air compressors that made up our profile.

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Here's the overall operating summary of the system and we go on to the contribution of each individual air compressor.

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Remember, we looked at that chart as to how much kW it was producing and how much air-flow it was contributing. Well, these are the actually raw numbers that were behind that bar chart that we looked at and there's the total for the system a $149,000.00 a year using 2.5 million kW hours.

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So, we could go on and on, and I know that we were scheduled for two hours, it's been two hours now but I think we warned you that we might go a little bit over because this is the first time out of the block so we had a lot of information that we wanted to show you guys.

So, at any rate, that's it as far as the demonstration stuff that I had intended. Let me just jump back over to the PowerPoint and I'll put up this – these are some of the sites where there's a bunch of stuff available – and Darryl before I kick it back to you to wrap up, do we have more questions here that we need to cover?

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Darryl: A couple of questions, one of them you just answered with the length and that was where someone can get a copy of the software – that's on the screen right now. There was another question if you'll take a look – it says, "Can LogTool now calculate volts for you from the amperage measurements."

Tom: Yeah, actually if your using volts with amps as the input to AIRMaster+, the most accurate way to create this profile here is to actually data log the voltage and data log the amperage both.

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But in this particular instance what we did is, we data logged only the amperage and the voltage we just took off the nameplate of the compressors, we didn't even do a spot measurement of that.

And so, AIRMaster+ uses the volts and amps to calculate kW and it uses the formula volts times amps times the square root of three times power factor divided by a thousand equals kW from a measured VA – volts amps – and so that formula is being calculated in the background here in AIRMaster+ and it is calculating kW from what the profile input that we showed here and again to make this profile most accurate, you'd probably want to go ahead and get a straight kW measurement.

Although, on these short-term three day Save Energy Now Assessments, we typically don't take the time to hook up kW instrumentation instead we just toss on some amp clamps and hook them to the data logger. So, hopefully that was responsive to that question.

Darryl: We got a couple more that just rolled in.

Tom: Okay.

Darryl: And they keep…

Tom: Repeat – oh, yeah repeat how you were able to have the system consider the combination of the four systems. That's a really good question and I did a little bit of a short cut there. Larry, you caught my slight of hand because what I – well, let me talk about – first of all what might be more appropriate to do.

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If we created – this is where you create systems and you'll notice that I created only one system and by rights this should have been three systems. The Building 1, the Building 2, 3 and 4 system and the analysis would have included those separate three air systems. To combine those systems into one, I would have to make another AIRMaster+ model with all the data for all three systems in one model and that's the model that I'm showing you.

This one is all those things combined. Now, it doesn't really affect the baseline because the profile is measured. It is what it is. So, the total of running all three systems is this, but if we wanted to have the number of the annual operating cost for each of the three systems, we would have to create multiple system within the AIRMaster+ model and so unfortunately, AIRMaster+ doesn't let you create three systems and create a model based on that and then simply push a button and say, "Hey, combine these into one system now and tell me what happens."

AIRMaster+ doesn't do that automatically, you have to create a separate model and in this particular case that's the model I'm showing you, so that's a very good question. Where are we now? Oh, there's a question here about what would be the average cost of the AIRMaster+ software? An average cost – the software is free. Go to the website and you can download it. LogTool is also free. They've been developed through initiatives through the Department of Energy and Compressed Air Challenge and SBW Consulting and Washington State University and we can thank those folks for making us some pretty nifty tools.

Do you remember flow controllers or compressor controllers based on system in the pressure – system pressure? Yes, flow controls have a place in systems and it's quite a bit more in-depth training to really understand flow controllers and their total impact on the system and that's where there is compressor air challenge training and there is AIRMaster+ – qualified AIRMaster+ specialist training – and if you go to the Web sites that I've got up here on the screen right now.

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There are training calendars there – the training information and calendars you would find are – Compressed Air Challenge have the fundamentals of Compressed Air System one day class and Advanced Management Air System two day class plus there's the AIRMaster+ Qualified Specialist which is the third class is about a week long and the calendars are maintained there.

And in the AIRMaster+ Qualified Specialist class, AIRMaster+ does not directly model pressure flow control but there's a work around AIRMaster+ does not presently model BSD Compressors but there is a work-around and during the AIRMaster+ class, we teach you about those work-arounds in the software and how you can make it do some things that it won't immediately do by itself.

Is LogTool only for Compressors or can it be used for other data analysis?

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No, LogTool can deal with any type of data at all and it is just whatever you put in and if you were to say have a pump flow of GPM and you wanted to do the hourly averages – what's the hourly average flow of this pump or whatever data stream you have - you could do a Day Type of a pump flow profile and it would give you what you got here.

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The only drawback to that is that when you go to this – and I didn't use it – you go to the units, you can put in any type of units you want but you go to type and you see the type is power, pressure, flow, current or other. So, the only thing you can do is toss in GPM and call it, "Other" and it will show up on the charts as other but you would know it was GPM.

So, this is the only field that's a bit limiting and it's really geared towards use in compressed air systems but the software doesn't care what the data streams are, it can represent anything that you want it to represent. What power factor is being consumed in the wattage calculations, does it change with compressor loading? And the answer is yes, it does change with compressor loading and the way it does that – let me get out a LogTool and go back to AIRMaster+.

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When we define a Compressor, you come into a Compressor and you've got a drive motor and you define the drive motor in here and then based on that it's just going to use a generic curve or if we were to change this and come in and edit it where we go to the drive mode or if it was a designed D or high starting tork or Nema design A or two speed variable tork or whatever, it would have adopt the power factor versus percent full load amperage characteristics of the motor. I believe it defaults to Nema designed B. So, that's how that handled. Any other software tools other than AIRMaster+ for compressed air? No, not really there are other proprietary tools but those are typically manufactures specific and Chuck Thornton said that, "It was well worth my time, look forward…" Well, thank you Chuck, I appreciate that.

Any other questions that came up there? Darryl?

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Darryl: Sorry, I had that muted. No, I don't see anything else.

Tom: Okay, you want me to drive and you can just go through the wrap up then here?

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Darryl: Sure, that'll be fine and since the slides are going to be distributed and the links are already on the slides are already on the slides, I'm not going to take peoples time right now because we are over our limit except to explain that yes, there is the ability or the capacity out there to also use this for estimating green house gas emission and reductions. You can scroll through the slides there.

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The links are going to be on the slides. There's a link on here for where to get the estimator. It's a free download from the DOE Web site.

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You can flip over one more. There we go at the top of the page it's the actually link for getting the estimator. So, we're good and I think we've got one more slide here.

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Okay, it's going to be two more but it's going through the EPA calculators and the next one you can go to the FEM greenhouse Web site.

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There are additional resources out there and it will also give you some other information on dealing with the greenhouse gas emissions. One more.

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FEMP's Technology Deployment area, those resources are listed, obviously I'm not Tom Wenning, I'm filling in for him because he ended up on travel today unexpectantly but Tom's contact information is available. Also the ITT best practices information for all the software tools. There are tools and pumps, fans, steam, obviously compressed air and processed heating in addition to motors themselves, next.

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There's been a lot questions about slides. Slides will be made available and as long as I don't mess it up real bad the training was recorded. We'll have to do a conversion to get that into something that's readable by normal video players like Windows Media Player. We'll be taking care of that this evening and you should hear from us tomorrow as far to get the video. If you do the course evaluation at which Tom Wenning will be sending out – like I said he's on travel – but he'll probably be sending it out this evening or first thing I the morning. The two professional development hours are available.

Tom: And I'd like to say, thanks everybody for attending, I apologize we went a little bit over, it's a first time that we've actually done this presentation and I hope it was worth your time and we're certainly interested in your comments on the comment form that's going to be sending out and anything we can do to improve things, we certainly want to take that into account. So, thanks again to everyone for attending.

Darryl: And I definitely want to thank Tom for the presentation, I think it was very well done and I think it was informative and I've been doing this for a while and Tom knows that and I still learned a lot also. So, thank you very much.

Tom: Okay.

Darryl: And I don't see any new ones coming in folks, so Tom I think we're done.

Tom: Yep.

Darryl: Okay, thank you very much. I've got it now and I'll start. Okay, you gone Tom?

Tom: I'm still here but…

Darryl: Well, I think what I'm going to do is just stop the recording and grab some of the Go-to-Meeting type metrics as far as number of attendees and some of the list and things and then get started on converting the video file and that kind of stuff.

Tom: Right.

Darryl: So, I think we're in good shape.

Tom: Yeah, so it's stop presentation.

[End of Audio]